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FORTY-FIFTH

PROGRESS REPORT

OF

THE FIRESTONE TIRE & RUBBER COMPANY

ON

BATTALION ANTI-TANK PROJECT

UNDER

Contract No. DA-33-019-ORD-1202

ORDNANCE DEPARTMENT PROJECTS
TS4-4020—WEAPONS AND ACCESSORIES
TM1-1540—AMMUNITION

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COPY No. 51

THE FIRESTONE TIRE & RUBBER COMPANY
Defense Research Division
Akron, Ohio

APRIL 1954

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FORTY-FIFTH

PROGRESS REPORT

OF

THE FIRESTONE TIRE & RUBBER CO.

ON

BATTALION ANTI-TANK PROJECT

Contract No.
DA-33-019-ORD-1202

RAD Nos. ORDTS 3-3955
ORDTS 3-3957
ORDTA 3-3952

THE FIRESTONE TIRE & RUBBER CO.
Defense Research Division
Akron, Ohio

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ABSTRACT

General Projectile Design Considerations - In considering a 90mm weapon and ammunition for the requirements of the ultimate BAT system it is necessary to obtain penetration performance equivalent to that of the 105mm round. To reach this performance the cone size of the 90mm round must be approximately equivalent to that of the 105mm round. In order to use a cone of this size a method of assembly, using plastic bonding agents has been devised. This method permits thinner wall sections and hence larger diameter cones. The method to be used in bonding the ogive and body has been tested in the laboratory and the strength of the union measured. The test procedure and results are discussed here. It was found that the walls of the components failed before the separation of the cemented joint.

A new fin assembly has been designed for folding fin type projectiles. The new assembly is in the 90mm size but the design can be adapted to other sizes as well. The new assembly has fewer parts, provides more positive locking of the fins and is designed so that more generous tolerances are permissible. The new design is illustrated and described.

Fuzes - Laboratory tests have been conducted to compare a new potted "Lucky" nose element with the present package unit. The test data are presented.

Fourteen rounds containing T267E14 base elements were fired for functioning evaluation at Erie Ordnance Depot. Six rounds functioned as set and eight rounds functioned either improperly or not at all. Because of poor conditions for observation the test is to be repeated.

Fourteen T267E14 base elements were fired at Aberdeen Proving Ground for graze sensitivity tests. Seven rounds functioned high order, 3 functioned low order and 4 rounds did not function. The test results are tabulated.

GENERAL PROJECTILE DESIGN CONSIDERATIONS

Design To Increase Diameter Of Conical Liner Diameter

In considering a 90mm weapon and ammunition for the requirements of the ultimate BAT system the penetrating ability is one of the prime considerations. Since comparative performance is the basis for selection of the caliber of the ultimate weapon and ammunition it is necessary to obtain penetration performance with the 90mm round equivalent to that of the 105mm T119E11 (M344) projectile. Since the penetration performance of shaped charges scales approximately linearly with cone diameter, it is evident that a proposed 90mm shell will penetrate as deeply as an existing 105mm size only when (1) the cones are of nearly the same effective diameter or (2) if the general level of shaped charge performance is improved.

Fig. 1 shows views of a 105mm HEAT round (T119E11) and the E1 modification of the 90mm BAT round designed by Firestone. In this E1 modification the effective cone diameter is 2.748 in compared with 3.555 in for the 105mm HEAT round, T119 E11. In order to lessen this differential, investigations are being made into new methods of assembly of the cone, body and ogive.

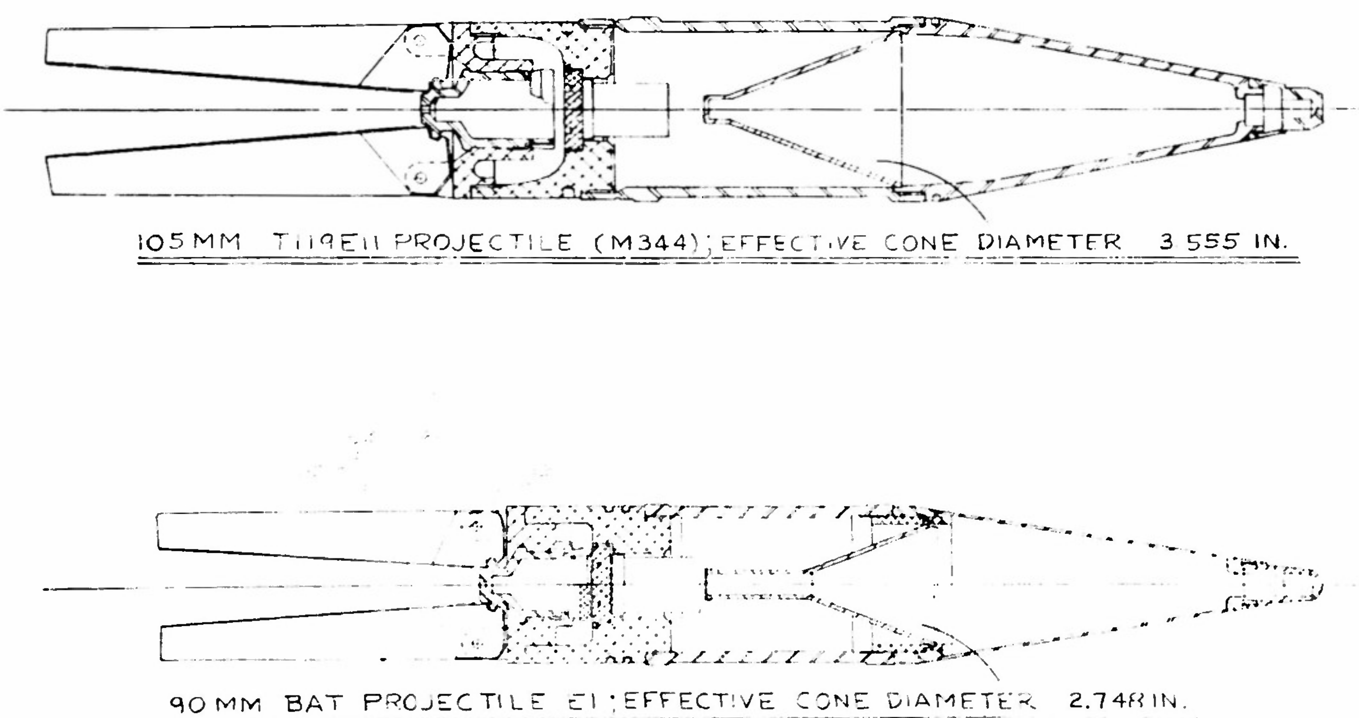


Fig. 1. Views Of Two Projectile Designs.
105 mm. BAT T119E11 (M344) and 90 mm. BAT E1.

Assembly Of Projectile Components With Plastic Bonding Agent

Fig. 2 shows the E2 modification of the BAT 90mm projectile, using a cone with an effective diameter of 3.248 in only 8.6% less than in the 105mm round. The assembly, shown in Fig. 2, is made by registering the cone in the body and locking it in place by crimping the flange down over the cone edge. The ogive is then cemented, pressed on the body and cured at approximately 200°F. The following tests have been conducted on this cemented joint.

Shear Strength Of Bonding Agent

Six test units were prepared as shown in Fig. 3. When the two pieces were assembled as shown, there was a circular lap joint 15/16 in. long. The other end of the test cylinders were machined to accommodate fixtures for applying a tensile load to produce simple shear across the joint.

The samples were carefully measured to determine the clearance within the joint, and the amount of ovality and the surface finish were noted. Table I shows these data.

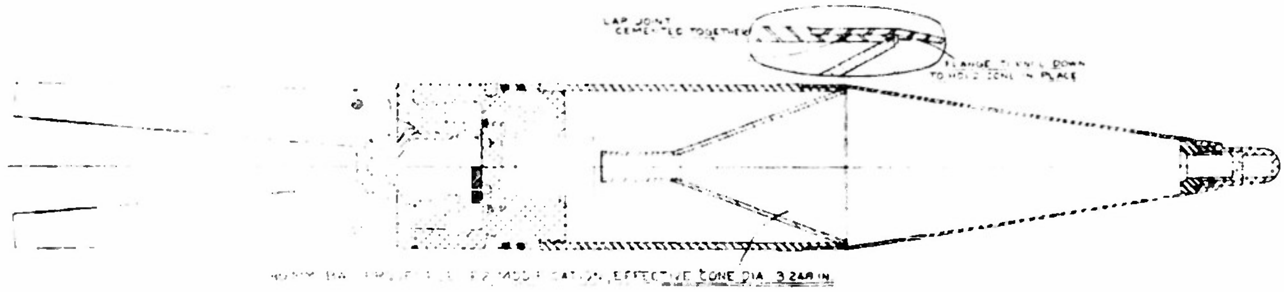


Fig. 2. 90 mm. BAT Projectile, E2 Modification.
Showing Assembly By Means Of Plastic Bonding Agent.

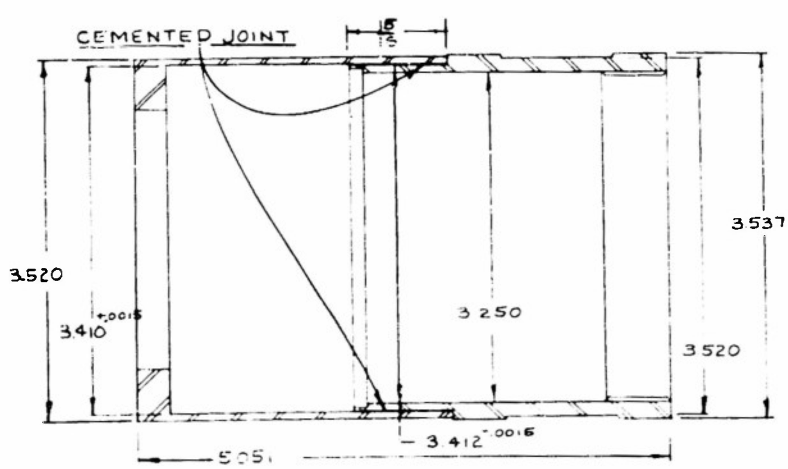


Fig. 3. Test Unit For Measuring Shear Strength Of Bonding Agent.

Table I
Inspection Data
Six Sample Test Assemblies

Sample	Avg. O.D. Male (in.)	Avg. I.D. Female (in.)	Clearance Avg (in)	Ovality Male (in)	Ovality Female (in)	Area of Joint (Calc.)(sq in)	Finish in Micro Inches Male	Finish in Micro Inches Female
1	3.407	3.415	.004	.0015	.002	10.2	130	140
2	3.408	3.417	.0045	.0005	0	10.2	90	150
3	3.407	3.412	.0025	.0005	0	10.2	100	220
4	3.407	3.415	.004	.0015	.002	10.2	220	90
5	3.410	3.418	.004	.001	.001	10.2	100	250
6	3.407	3.417	.005	.0005	.001	10.2	160	175

Three methods of surface preparation were used in preparing the samples:

(1) Samples 1, 3 and 5 were vapor degreased, liquid honed until free from a water break and blown dry with compressed air.

(2) Samples 2, 4 and 6 were vapor degreased, cleaned with an alkali cleaner, rinsed in cold water and blown dry with compressed air.

(3) After the treatments shown in (1) and (2) above, samples 5 and 6 were given a phosphate treatment for three minutes in Bonderite 160 and blown dry.

In all cases care was taken not to touch the joint area after cleaning.

Fifty grams of Shell Epon Adhesive VI were mixed with three grams of Shell Curing Agent A and applied to both male and female parts with a clean varnish brush. An effort was made to cover the surfaces to be joined completely while keeping the cement coating as thin as possible. The two parts were pressed firmly together by hand and rotated 360° with respect to each other to help to insure a proper distribution of cement. All excess cement was wiped off the inside and outside surfaces. These assemblies were cured as follows:

Samples 1, 2, 5 and 6 cured at 200°F for 45 minutes.

Samples 3 and 4 cured at 165°F for 2 hours.

No pressure was applied during curing and all samples were allowed to cool to room temperature and stand for several hours before testing.

The test results are summarized here and the complete data appear in Table II.

(1) Shell Epon VI cement produced bonded joints with a shear strength in excess of 3500 psi when the joints were liquid honed prior to assembly.

(2) Liquid honing the joints prior to bonding resulted in stronger joints than when the machined surfaces were chemically cleaned only, but the actual amount of increase in strength could not be determined since the strength of the joint exceeded the strength of one of the components.

(3) Changing the curing cycle from 45 minutes at 200°F to 2 hours at 165°F resulted in no appreciable difference in the strength of the joint.

Table II
Test Results
To Test Strength of Plastic Adhesive

Sample	Ultimate Load	Shear Load (psi)	Comments
1	37,800 lbs.	3,700	Shell body fractured.* No separation of joint.
2	33,600 lbs.	3,300	Lap separated. Air pockets in cement.
3	37,600 lbs.	3,700	Shell body fractured.* No separation of joint.
4	37,600 lbs.	3,700	Lap separated. Cement job appeared to be satisfactory.
5	33,900 lbs.	3,500	Shell body fractured.* No separation of joint.
6	26,500 lbs.	2,600	Lap separated. Cement job appeared to be satisfactory.

Sample No. 1 loaded at a rate of 2,000 lbs. per minute.

Balance of samples loaded at a rate of 4,000 lbs. per minute.

* Cross sectional area of body at point of failure is .57 square inches, so failure of metal occured at a stress of 66,300 psi.

Folding Fin Projectile

A new fin assembly for folding fin type projectiles has been designed to replace the type of fin assembly used on the T119E11 projectile and on the BAT 90mm projectiles, modifications E1 through E4. The new fin assembly design is illustrated and compared with the T119E11 fin assembly (M8) design in Fig. 4.

The major objectives of the new fin assembly are as follows:

(a) more positive locking of the fins.
(b) fewer parts
(c) will permit loose tolerances.

The folding fin mechanism is required to function only once, but that one performance must be such that the fins are accurately positioned and locked when open. Loose tolerances are permissible if such tolerances do not influence proper functioning. This is believed to have been accomplished in the new design.

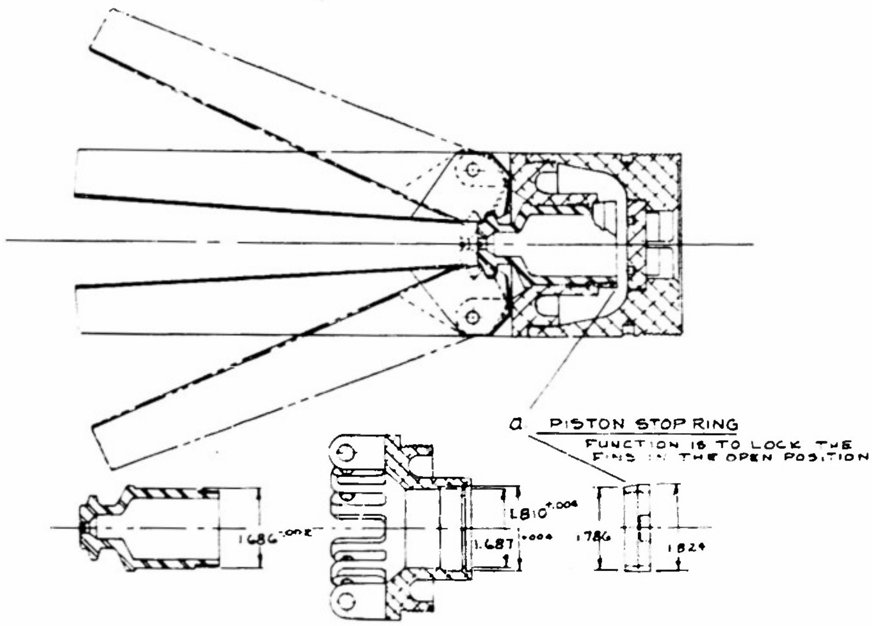
The following design changes can be noted in Fig. 4.

1. More positive fin locking. The function of the piston stop ring, a, in the T119E11 fin assembly (M8) is to lock the fins in the open position. In the new design the fins are locked open when the piston, b, drives past the fin lug.

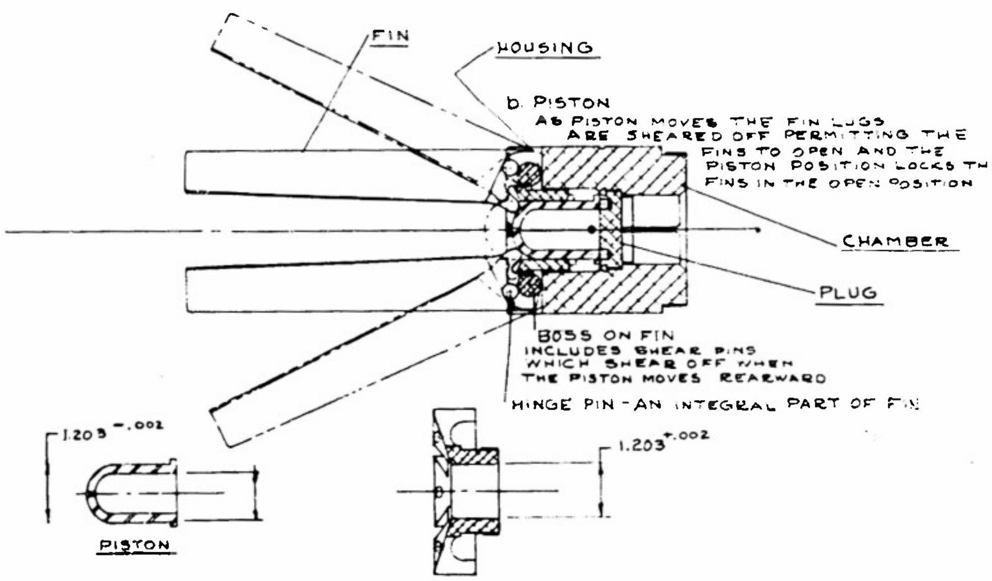
2. Hinge pins have been incorporated into the fin forging. The fin can be assembled just as it comes from the forging die, thus eliminating the precision machining required on the M8 fin.

3. The fin housing and piston are designed to require a minimum of precision machining.

Future planning includes the investigation of die castings for the fin housing and a stamping for the piston which if feasible, will reduce the cost of the assembly still further.



T119E11 FIN ASSEMBLY (M8



90 MM BAT FIN ASSEMBLY DRC-15-860

Fig. 4. Comparison Of Fin Assembly Designs.
T119E11 Fin Assembly (M8) and DRC-15-860 Assembly.

Potted "Lucky" Nose Element

In an attempt to improve the ground impact sensitivity of projectiles developed by Firestone, considerable attention is given to the potted "Lucky" nose element described in the Forty-Second Progress Report and illustrated in Fig. 5. A thorough dynamic test of the potted unit is scheduled for firing at Aberdeen Proving Ground during the month of May. In conjunction with this study, laboratory comparison tests have been made with the potted unit and the package unit now in use (shown for comparison in Fig. 5).

A small pendulum was used to strike the "Lucky" units with impact velocities ranging from 2 to 9 fps and a minature air gun was used to strike the units with impact velocities ranging from 60 to 80 fps. Curves showing a comparison of voltage output versus impact velocity and voltage output versus kinetic energy are presented in Figs. 6-9, inclusive.

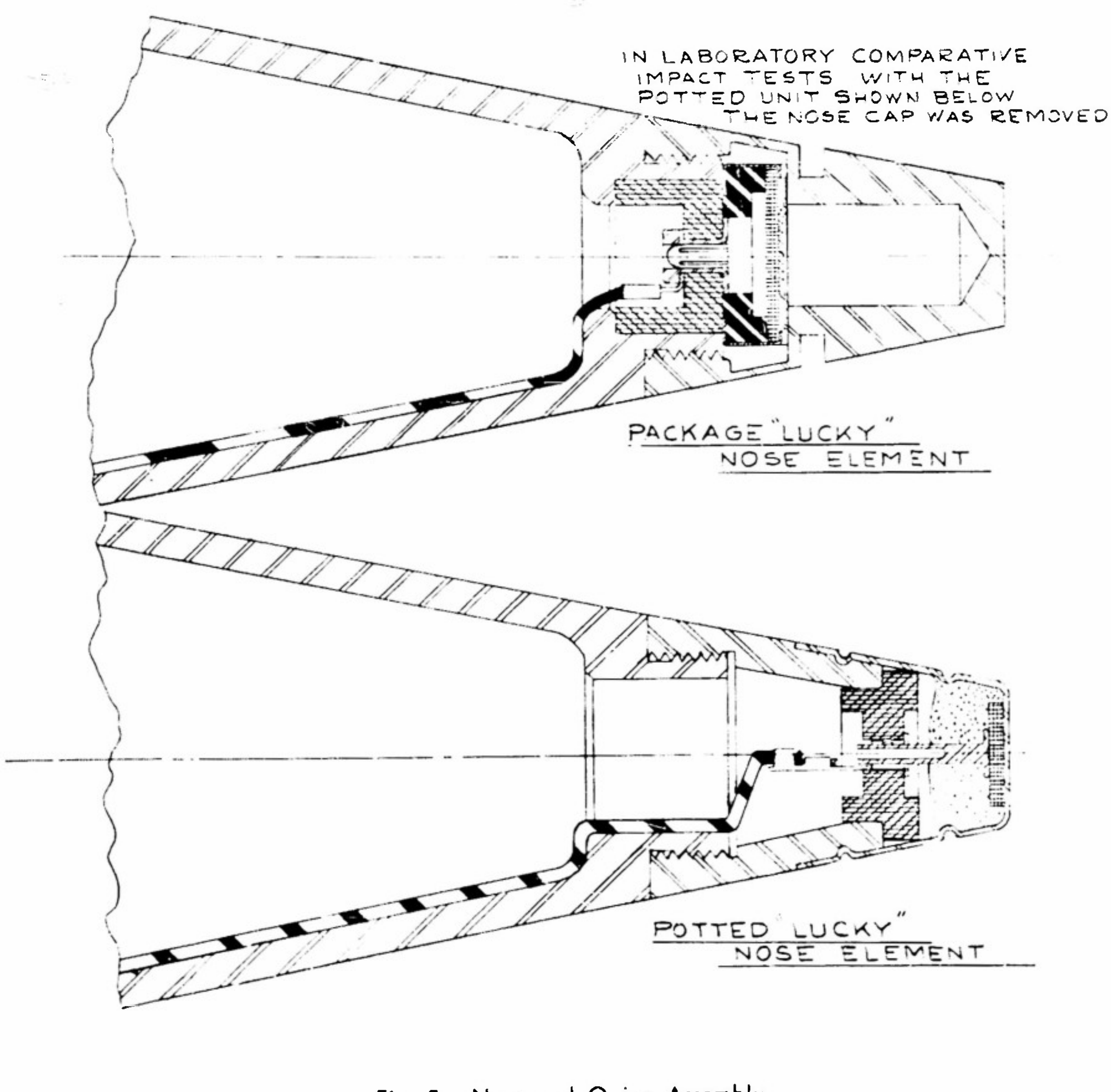


Fig. 5. Nose and Ogive Assembly.
With Potted "Lucky" Nose Element.

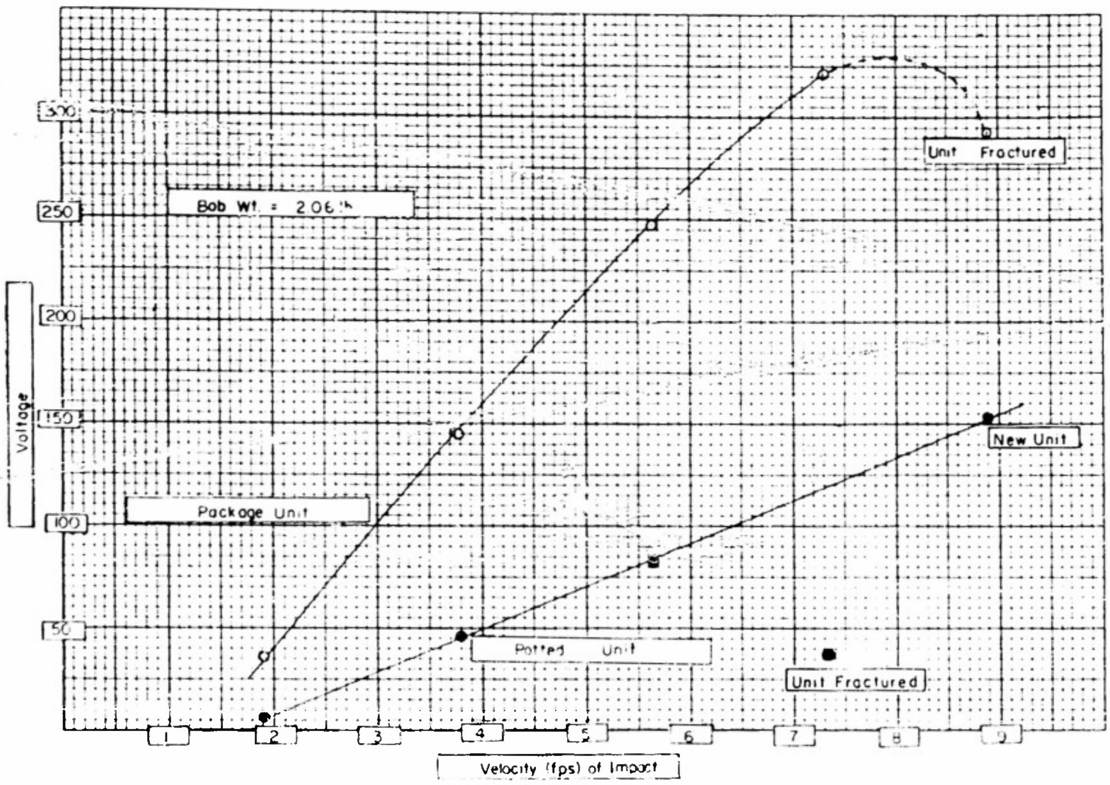


Fig. 6. Voltage Output Versus Velocity Of Impact.
Package "Lucky" and Potted "Lucky" Units.
Using Pendulum Impact: 2 to 9 fps Velocity.

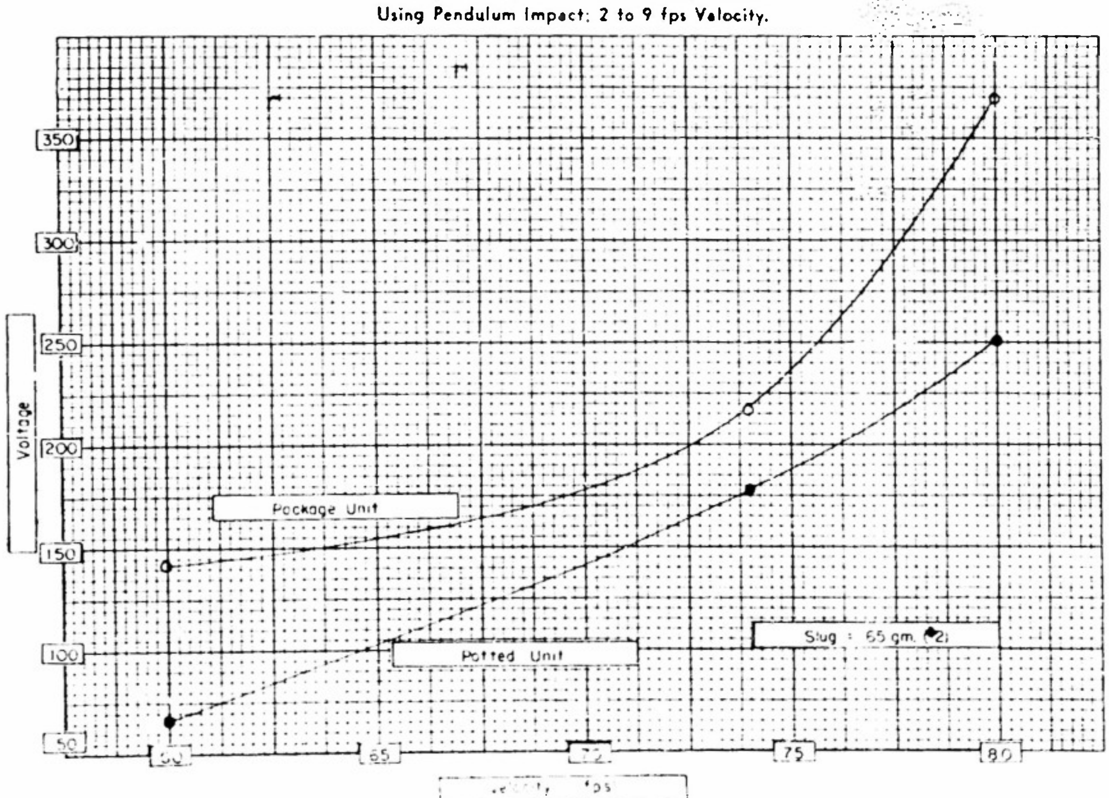


Fig. 7. Voltage Output Versus Velocity Of Impact.
Package "Lucky" and Potted "Lucky" Units.
Using Air Gun Impact: 60 to 80 fps Velocity.

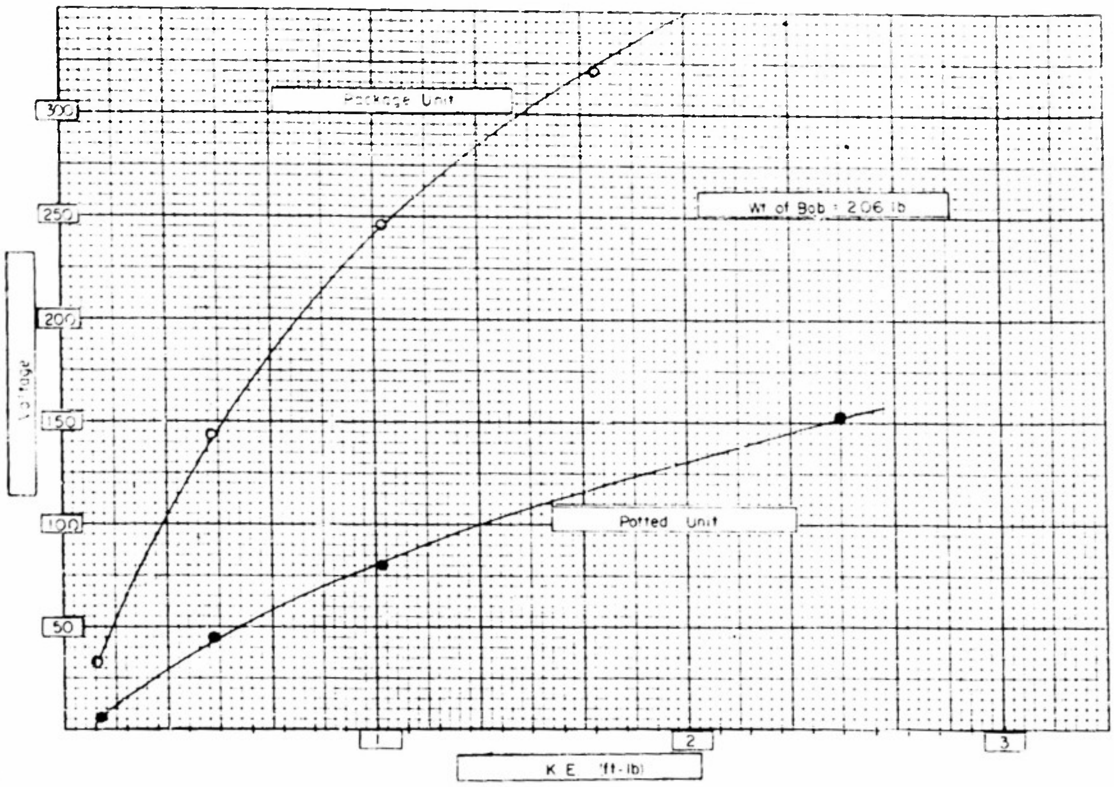


Fig. 8. Voltage Output Versus Kinetic Energy.
Package "Lucky" and Potted "Lucky" Units.
Using Pendulum Impact; 2 to 9 fps Velocity.

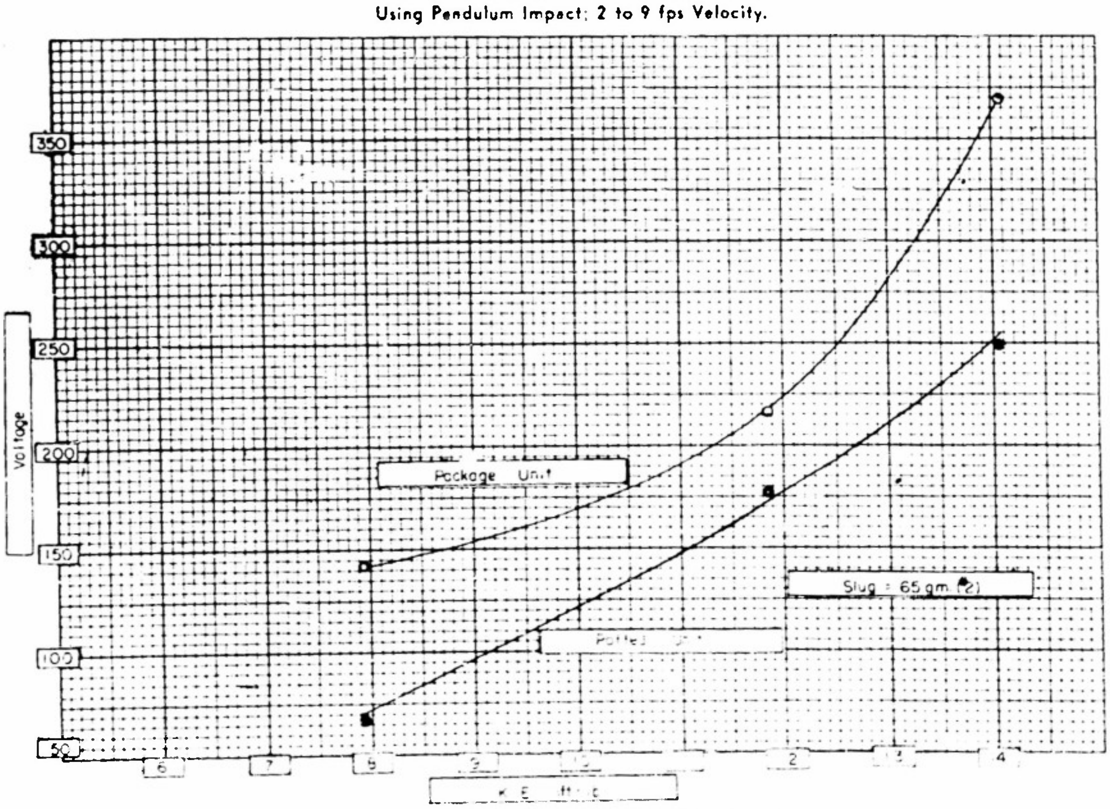


Fig. 9. Voltage Output Versus Kinetic Energy.
Package "Lucky" and Potted "Lucky" Units.
Using Air Gun Impact; 60 to 80 fps Velocity.

T267 Base Element

Fourteen test rounds containing T267E14 base elements (Fig. 10) were fired at Erie Ordnance Depot to determine the percentage of functions of a lot of 100 fuzes manufactured by the Corry Instrument Company, Corry, Pa. Eight rounds were set for delay and six rounds for superquick functioning.

Four "delay" rounds (50%) and two rounds set "superquick" (33 1/3%) functioned satisfactorily. The remaining four rounds set "superquick" functioned "delay" and the remaining four "delay" rounds failed to function. Observation of these rounds was very poor. It is believed that the spotting charge was not sufficient for consistent observation. Table IV is a copy of the firing record. It is planned to repeat this test using an improved spotting technique.

Fourteen rounds containing T267E14 base elements were fired at Aberdeen Proving Ground for graze impact functioning. These rounds were fired at medium soft earth at ranges of 250 ft to 1000 ft. The results of the test are shown in Table III.

The base element is designed so that functioning should not occur unless the rotor has turned to the armed position (see Fig. 10). The reason for the low order functionings (Table III) is not known. The inertia element is designed to require a change of velocity of 30 fps to produce functioning. Previous tests have shown the element to function on one inch of pine.

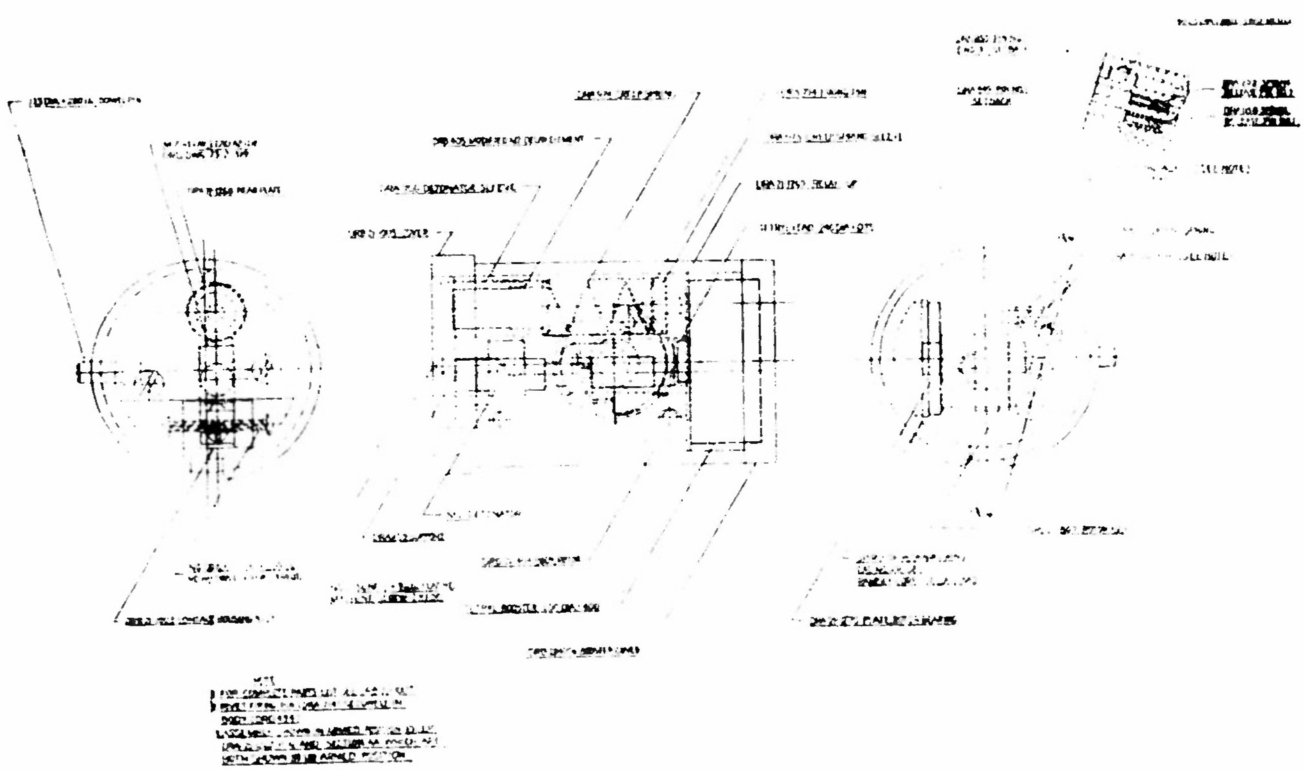


Fig. 10. T267E14 Base Element.
Firestone Drawing No. DRD-21-493.

Table III
Functioning Of T267E14 Base Elements
On Graze Impact "Lucky" Not Connected

Round No.	Range At Which Round Functioned	Type Of Functioning
1	1100	High Order air burst
2	1050	High Order
3	First impact - 700 ft.	High Order in woods after skipping
4	1050	High Order
5	Hit at 700 ft.	Did not function
6	Hit at 700 ft.	Did not function
7	Hit at 900 ft.	Did not function
8	Hit at 1050 ft.	Low Order
9	Hit at 1025 ft.	High Order ground blast
10	Hit at 1050 ft.	Low Order
11		Did not function. Hit in woods.
12	700	Low Order
13	470	High Order air burst
14	Hit at 350 ft.	High Order down range

Future Program

1. Fire T267E14 base elements at Erie Ordnance Depot using improved spotting methods.

2. Fire a dynamic test of the potted "Lucky" at Aberdeen Proving Ground.

3. Continue efforts to reduce the size of the T267 base element.

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Table IV
Test Data
Functioning Tests With T267E14 Base Elements

Sheet 1 of 1

Date of Test 4 May 1954
Location Erie Ordnance Depot

Purpose of Test To Test Functioning Of T267 Fuzes
Lot of 100 manufactured by [illegible]orry Instr Co
Program No. 135

PROJECTILE
Model T119E11
Type Experimental Projectile
Weight 16.67 lb (Nominal Weight)
C.G. Location —
Bourrelet Dia 4.132 in
Retard Factor 0.195 ft/sec/ft
Special Features T267 Fuze with base element and two extra tetryl pellets

TEST GUN
Model T19
Type 105mm Recoilless
Serial No. 6
Chamber 26694-1-12931
Bushing(Vent) VA884
Tube No. 6 12742-2656-2 1/20 twist
Sighting Equip Telescope, Elbow, M17 No 132275
Mount:
Type Old Pend. Ser. No ___
Constant 2.68 lb-sec/in
Firing Mech Electric

MISCELLANEOUS DATA
Range Bursting Screen
Muzzle to Target: C 475 ft
Propellant:
Type MP M10 Web 0.035 in Weight 7 lb 14 oz
Lot No. PA 80259
Primer M57
Shell Case T53E1
Liner T4E1
Temperatures:
Magazine
Max. 73°F Min. 71°F Present 72°F
Loading Room 63°F Ambient 40°F

Round Number	Proj. Number	Proj Weight (lb)	Propell. Weight (lb - oz)	Chamber Pressure (psi) (Cu)	Chamber Pressure (psi) (Internal M3)	Muzzle Velocity (fps) Instr.	Muzzle Velocity (fps) Actual	Azim (mils)	Fuze Function	Position of Hit (inches) Vert.	Position of Hit (inches) Horiz.	Corrected Posit. of Hit - (mils) Vert.	Corrected Posit. of Hit - (mils) Horiz.		Type Fuze		Observations
7146 1	X1950	16.68	7-14	8000	8000	1686	1701		Yes						Delay	1	Functioned behind target
7147 2	X1944	16.69	7-14	7400	9000	1670	1685		No						Delay	2	Not observed to function. Hit in almost same hole as round 1
7148 3	X1941	16.65	7-14	7400	8800	1662	1677		Yes						Delay	3	Small, low cloud of smoke 50 ft to 100 ft behind the target
7149 4	X1942	16.66	7-14	7400	9000	1683	1698		No						Delay	4	Not observed to function
7150 5	X1936	16.66	7-14	8500	8400	1656	1671		No						Delay	5	Not observed to function. Made water splash behind 300 yd dike.
7151 6	X1943	16.69	7-14	7400	8100	1628	1643		Yes						Delay	6	Small smoke behind target. Functioned just behind target
7152 7	X1945	16.68	7-14	8400	8200	1663	1678		No						Delay	7	Not observed to function
7153 8	X1949	16.65	7-14	8700	7100	1673	1688		Yes						Delay	8	Functioned behind target
7154 9	X1946	16.62	7-14	8000	9000	1681	1696		Yes						Super quick	9	Functioned behind target. Approx at 300 yd dike.
7155 10	X1940	16.69	7-14	8200	8500	2021	2036		Yes						Super quick	10	Functioned on target. Flash at target. One observed just behind
7156 11	X1937	16.64	7-14	8300	8500	1689	1704		Yes						Super quick	11	Functioned 200 yds behind, then clipped tree
7157 12	X1939	16.63	7-14	—	8000	1654	1669		Yes						Super quick	12	Functioned on and just behind target
7158 13	X1948	16.76	7-14	9000	9100	1632	1647		Yes						Super quick	13	Functioned about 400 yds behind target
7159 14	X1938	16.71	7-14	8400	8300	Start	Only		Yes						Super quick	14	Functioned about 100 yds behind target in air
15																15	
16	Avg	16.67			8350		1679									16	
17							Omitting	Rd. 10.								17	
18																18	
19																19	
20																20	
21																21	
22																22	

Muzzle — 59.18′ — 1 — 50.32′ — 2
Screen (Coil) Distances

Proof Director E. Huffman Signed W. W. McMillan
Observers W. L. Russell, Jr

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MANUFACTURING SUMMARY

In addition to the experimental material prepared for the research and development work under contracts DA-33-019-ORD-33 and DA-33-019-ORD-1202, described in preceding progress reports and in the preceding pages of this report, the following have been manufactured and shipped to the installations indicated.

Firestone's Defense Research Division, in shipping these items, transfers custody and control of the items to the receiving agencies. However, personnel of Defense Research Division will continue to collaborate with personnel of the other installations.

I. Cartridges, HEAT, 106mm, M344 (T119E11) Without Fuzes T208E7

Prior to	April 1, 1954	16,715	All Shipments
	No Shipments in April		

II. Rifles, T170E1 for ONTOS

Prior to	April 1, 1954	72	All Shipments
	April 17, 1954	12	Aberdeen Proving Ground
	April 24, 1954	18	Aberdeen Proving Ground
	April 30, 1954	18	Aberdeen Proving Ground
	Total	120	

III. Mounts, T173 and T26 Tripod for ONTOS

Prior to	April 1, 1954	22	All Shipments
	No Shipments in April		

IV. BAT Systems less Jeep, T170E1 (M40) Rifle, T149E3 (M79) Mounts (with latest modifications).

Prior to	April 1, 1954	25	All Shipments
	No Shipments in April		

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1	5	ORDT[illegible]
1	6	ORDT[illegible]
1	7	ORDG[illegible]-SE
1	8	ORD[illegible]
1	9	Diamond Ordnance Fuze Laboratory
		Arsenals
10	10-19 incl.	Frankford
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